EURO-CARES - HOW TO ADVANCE EUROPEAN EFFORTS TO HAVE A CURATION FACILITY FOR UNRESTRICTED AND/OR RESTRICTED SAMPLES FROM SAMPLE RETURN MISSIONS.

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Introduction: EURO-CARES (European Curation of Astromaterials Returned from Exploration of Space) was a three year (2015-2017), multinational project, funded under the European Commission's Horizon2020 research programme (Project ID# 640190). The objective of EURO-CARES was to create a roadmap for the implementation of a European Extra-terrestrial Sample Curation Facility (ESCF). Following some previous studies [1, 2, 3], which were typically either country-specific or mission/target specific, EURO-CARES moved onwards to look at what would be needed to create a European facility suitable for the curation of samples from all possible return missions, likely over the next few decades, to the Moon, asteroids, Mars, and other bodies of the Solar System (i.e., for both unrestricted and restricted samples).

The last deliverable of the EURO-CARES project (available on www.euro-cares.eu) was written to be a self-standing document, summarising all different aspects of the project, organized following a timeline, of all that should be considered to receive and curate samples from sample return missions. Here we summarize the main conclusions of this document.

Planetary Protection for restricted samples: In the case of restricted samples, the Planetary Protection (PP) requirements state that the probability of a single unsterilized particle of ≥0.1 μm being released in the environment shall be ≤ 1 x 10^{-6} [4] The measures already employed for high containment facilities (BioSafety Level 4 (BSL-4) laboratories) demonstrate that the majority of the technology necessary for a restricted Earth return mission already exists, and thus can be built upon with technologies adapted from different sectors of the industry [5]. However, the development of some new technologies, such as the double walled isolator, remote manipulation, integration of scientific analytical instruments, etc., is required. There will also be a necessity for specialized training in working with restricted samples for the ECSF staff.

Design of the ESCF: Different design solutions for the ESCF and its various functional units (i.e., each serving a specific purpose, see figure 1) were prepared in collaboration with architects. The different designs are all based on flexibility, whether it is at the level of the site, or at the level of the room. The ESCF, as a long-standing storage curation facility, and with the aim of accommodating samples from several sample return missions, should be easy to remodel if necessary. An evaluation of costs, and especially how to mitigate them has been conducted. The cost of the ESCF would range from 10M€ to over 100M€ for restricted samples.

PRF Unrestricted	PRF Restricted	Assessing, cleaning and packaging the spacecraft on the landing site. Delivery of the spacecraft to SRF.
SRF Unrestricted	SRF Restricted	Receiving the sample container, cleaning and opening of the outer layers and delivery of the unopened sample canisters to the curation facility. Clean environment. For restricted samples, containment environment required.
SCF Unrestricted	SCF Restricted	Receiving of the sample canister, accessing the samples. Preliminary Examination (sample and hardware) and Sample Early Characterisation, Curation and Dissemination. For restricted samples, Life Detection and Biohazard Assessment Protocol. Ultra-clean environment. For restricted samples, high containment environment required.
Work Space		Support space for workers (offices, meeting rooms, social rooms, restaurant, etc.).
Public Outreach		Space accessible to the public (different categories of public, TBD) to promote the activities of the ESCF.
Analogue and Mock-Up Facility		Personnel training, instruments and protocols testing on analogue samples. Material testing for cleanliness and containment suitability.

Figure 1: Functional units of the ESCF. PRF: Portable Receiving Facility; SRF: Sample Receiving Facility; SCF: Sample Curation Facility.

Recovery procedures: Lessons learned from past sample return missions show that the negotiations regarding landing site selection should start more than two years in advance of a mission (including regulations from the host country, visas, etc.), knowing that the training of the team for every possible scenario, environmental measurements and collection of samples for storage at the landing site (air, soil, flora and fauna, water) should also be completed in advance. Six landing sites were identified for a potential European sample return mission, including White Sands Area, Utah Test

and Training Range (UTTR) and Wallops in the USA, Woomera Range Complex in Australia, Kazahkstan and the Esrange Space Centre in Sweden. A trade-off table weighing various parameters is provided in the delivered document.

Characterization and study of the samples: As soon as the samples are returned to Earth, several stages of studies will be conducted.

Sample Early Characterisation (SEC). This phase of work consists of simple, non-destructive measurements to be completed to identify a basic description of each sub-sample. This phase should be completed as early as possible, and can start while the samples are still enclosed in the Earth Return Capsule (ERC). It is conducted within the ESCF, for both, unrestricted and restricted samples. The SEC enables the next steps of examination, and later on, the science to be conducted on the samples.

Preliminary Examination (PE). This phase aims at fulfilling the original scientific goals of the mission. For unrestricted samples, it is recommended to perform this phase outside of the ESCF, with partner laboratories. It would allow for the reduction of the footprint and costs of the ESCF, while involving the science community. In the case of restricted samples, the PE must be either conducted within the restricted area built according to Planetary Protection (PP) recommendations, or, if done in external laboratories, the samples must be either sterilised prior to sending, or enclosed in specific containers following the PP recommendations.

Life Detection (LD) and Biohazard Assessment Protocol (BAP). This stage only stands for restricted samples. It involves using a wide range of techniques to investigate the presence of past and/or present life in the samples.

Open phase of scientific investigations. Once the initial goals of the missions have been fulfilled, the samples should be made available to the large scientific community.

Extended activities: The various steps described above need to assemble a multidisciplinary scientific committee from the very beginning to state on protocols and instrumentations, and on potential allocation of samples. This committee is particularly necessary for the early phases (SEC, PE, and LD/BAP). Other work efforts must be conducted: set up and use of an analogue sample collection to test instruments and methods, and a comprehensive contamination knowledge and contamination control plan.

Major recommendations: We recommend as landing sites either UTTR, or the Esrange Space Centre. There is an urgent need to consolidate the protocols for LD and BAP, regarding restricted sample return, and to address the question of sterilization of samples. Selection and appropriate training of the staff is critical, and should be done years in advance, using the suite of analogue materials. Bringing back samples from Mars or other restricted bodies requires a new generation of curation facilities, which would utilise the latest technological developments to control contamination of both the sample and the environment.

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